WATER RESOURCES REVIEW for MARCH 1972

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CANADA
DEPARTMENT OF THE ENVIRONMENT
INLAND WATERS BRANCH

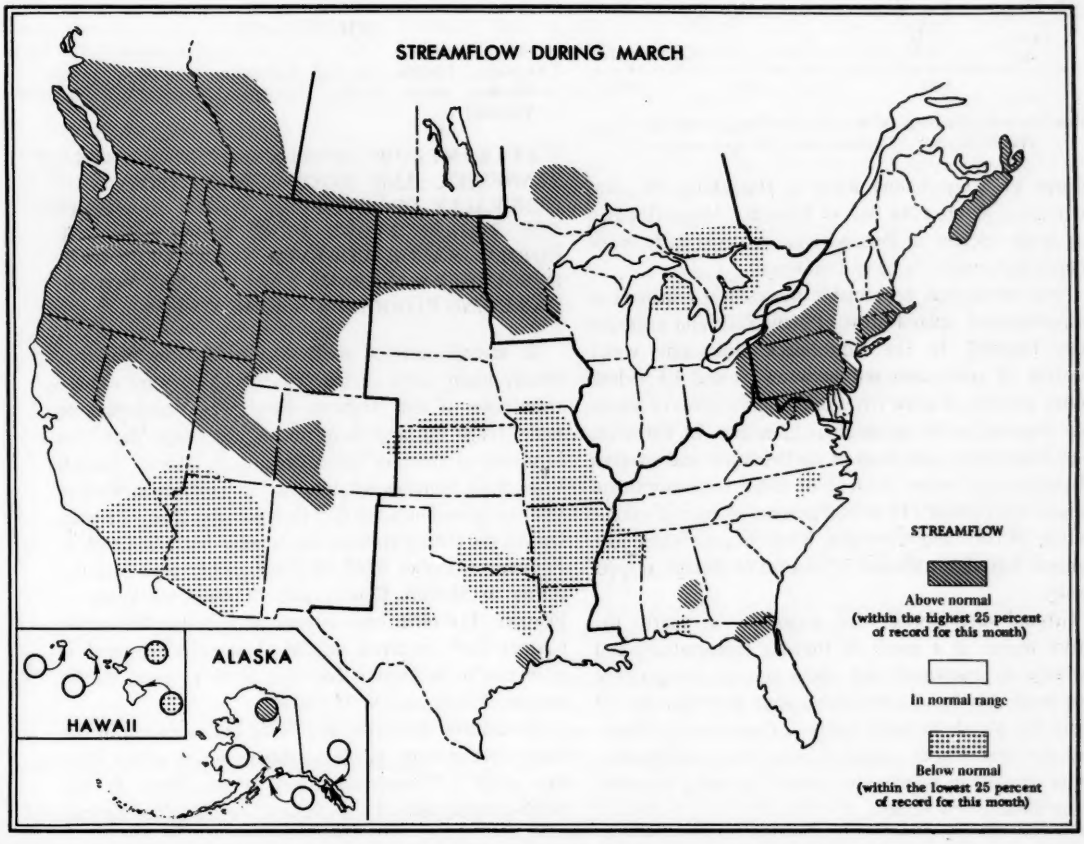
STREAMFLOW AND GROUND-WATER CONDITIONS

Streamflow increased and was far above normal in northern and central parts of the West as a result of record or near-record high March temperatures causing meltwater runoff from snowpacks, principally at low elevations in mountain areas. High carryover flows from February contributed to the high runoff in some areas such as in western Washington and Oregon. March rains also added runoff in some areas, especially in northern parts of the West. Heavy snowpacks remain at higher elevations, such as in Idaho.

Flows also increased and were above normal in several large areas of the Northeast, a result of above-average precipitation, and also (in the north) of snowmelt runoff. Water content of snow remained above average at monthend in some mountain areas of New York and northern New England.

Locally severe flooding occurred in southern Alabama on March 2, and in the Houston, Texas, area on March 20.

Below-normal streamflow persisted in Arkansas, Missouri, Arizona, southern California, and a few smaller areas.



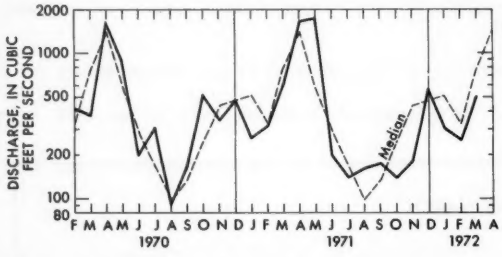
CONTENTS OF THIS ISSUE: Northeast, Southeast, Western Great Lakes region, Midcontinent, West, Alaska, Hawaii; Addition to series on water in the urban environment; Usable contents of selected reservoirs near end of March 1972; Periodic reports on ground-water levels in the United States, 1935–70; Two new publications on ground water; Flow of major rivers during March 1972; Underground storage of imported water in the San Gorgonio Pass area, southern California.

NORTHEAST

[Atlantic Provinces and Quebec; Delaware, Maryland, New York, New Jersey, Pennsylvania, and the New England States]

STREAMFLOW INCREASED IN MOST OF THE REGION. FLOWS WERE IN THE ABOVE-NORMAL RANGE IN NOVA SCOTIA, SOUTHERN NEW ENGLAND, AND IN A LARGE AREA CENTERED ON PENNSYLVANIA.

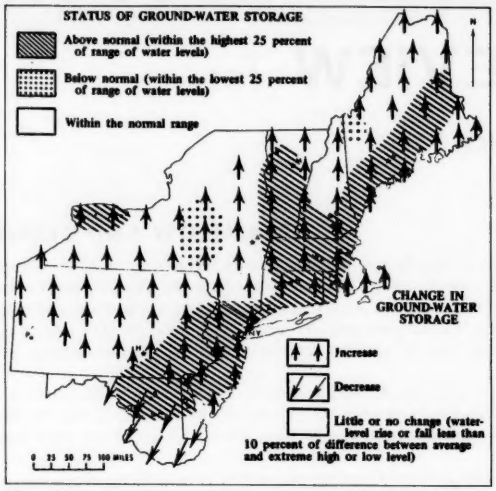
Above-normal precipitation accompanied by snowmelt runoff from upland areas, caused substantial increases in flow on many streams in the Northeast, including West Branch Oswegatchie River near Harrisville in northern New York (see graph). Monthly mean discharge of Susquehanna River at Harrisburg, Pa., was more than 4 times the flow of February. Minor flooding on some streams in Pennsylvania occurred early in the month as a result of rain and snowmelt.



Monthly mean discharge of West Branch Oswegatchie River near Harrisville, N.Y. (Drainage area, 258 square miles.)

Near monthend, appreciable snow cover remained in mountain and upland areas of New York and northern New England. In the Adirondack Mountains, water content of snow averaged between 10 and 12 inches. Water content of snow cover in mountain areas of Maine was reported to be as much as 12 inches. In Vermont, New Hampshire, and parts of north-central and western Massachusetts, water content of snow near monthend ranged from about 115 to 160 percent of average except in the Millers and Chicopee River basins, where the content was about 90 and 75 percent of average, respectively.

Ground-water levels rose seasonally in nearly the entire region as a result of thawing temperatures and recharge by snowmelt and above-average precipitation (see map). Levels near monthend were at or near record highs for March in some wells in Connecticut, Massachusetts, and Rhode Island. Levels were considerably above normal in many other areas, including much of Vermont and New Jersey.


STATUS OF GROUND-WATER STORAGE
Above normal (within the highest 25 percent of range of water levels)
Below normal (within the lowest 25 percent of range of water levels)
Within the normal range
CHANGE IN GROUND-WATER STORAGE
Increase
Decrease
Little or no change (water-level rise or fall less than 10 percent of difference between average and extreme high or low level)
0 25 50 75 100 miles

Map shows ground-water storage near end of March and change in ground-water storage from end of February to end of March.

SOUTHEAST

[Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia]

STREAMFLOW INCREASED IN ALABAMA, TENNESSEE, AND MOST OF MISSISSIPPI, BUT GENERALLY DECREASED IN OTHER STATES IN THE REGION. FLOWS WERE MAINLY IN THE NORMAL RANGE. HOWEVER, FLOWS WERE HIGH IN SOUTHERN ALABAMA EARLY IN THE MONTH, INCLUDING FLOODING ON SOME STREAMS.

In several parts of southern Alabama, on March 2, locally heavy rains caused flooding along some eastern tributaries of the Alabama River. The accompanying table (page 3) and map show peak-stage data and locations of three of these streams. A 24-hour rainfall total of 11.5 inches was reported at Beatrice in Monroe County, including a fall of 9 inches in less than 12 hours. One of the stream stations described—Big Flat Creek at Fountain (number 4285 on map)—is located near the center of Monroe County and 15 miles southwest of Beatrice. The recurrence interval of the peak stream discharges that occurred on the 3 streams reported is estimated to be greater than that likely to occur on the average of only once in 25 years.

Streamflow decreased in Florida but remained in the above-normal range in the northeastern part of the State (see graph of Suwannee River at Branford). In the north-central part of the State, flow of Silver Springs

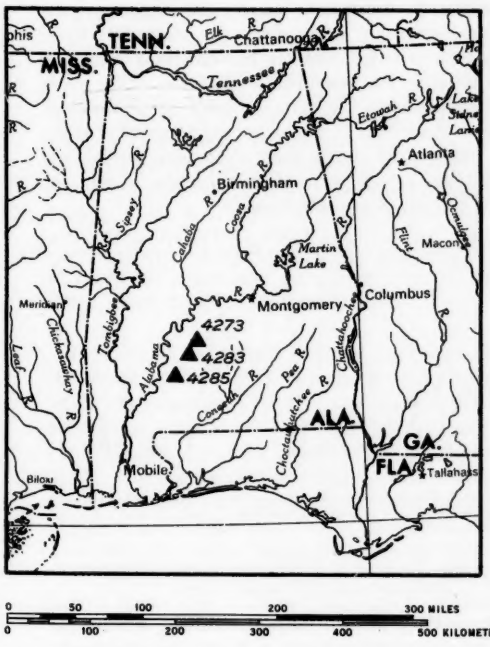
Provisional data; subject to revision

STAGES AND DISCHARGES FOR THE FLOODS OF MARCH 1972 AT SELECTED SITES IN ALABAMA AND TEXAS

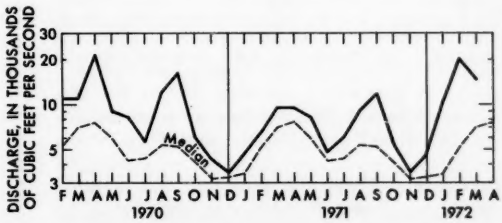
WRD station number	Stream and place of determination	Drainage area (square miles)	Period of known floods	Maximum flood previously known			Maximum during present flood				
				Date	Stage (feet)	Discharge (cfs)	Date	Stage (feet)	Discharge		Recurrence interval (years)
									Cfs	Cfs per square mile	
ALABAMA											
MOBILE RIVER BASIN											
2–4273	Prairie Creek near Oak Hill	9.73	1959–72	Feb. 24, 1961	14.15	1,690	Mar. 2	15.0	a	.....	>25
2–4283	Tallatchee Creek near Vredenburgh.	14.6	1958–72	Mar. 6, 1961	11.70	2,950	2	13.40	a	.....	>25
2–4285	Big Flat Creek at Fountain....	245	1944–72	Nov. 27, 1948	23.2	26,000	2	23.9	35,200	144	[b]1.1
TEXAS											
SAN JACINTO RIVER BASIN											
8–0741.5	Cole Creek at Deihl Road, Houston.	10.0	1964–72	Feb. 21, 1969	74.82	966	20	.....	2,100	210	25
8–0742.5	Brickhouse Gully at Costa Rica Street, Houston.	10.5	1964–72	May 10, 1968	65.94	2,280	20	.....	5,810	553	50
8–0745	Whiteoak Bayou at Houston..	84.7	1919–72	Dec. 9, 1935	51.5	14,800	20	.....	17,500	207	35
8–0765	Halls Bayou at Houston.....	24.7	1952–72	Sept. 12, 1961	.....	3,400	20	.....	3,740	151	12

[a]Discharge not determined.

[b]Ratio of peak discharge to 50-year flood.



Location of stream-gaging stations in Alabama described in table of peak stages and discharges.



Monthly mean discharge of Suwannee River at Branford, Fla. (Drainage area, 7,090 square miles.)

decreased by 10 cfs, to 740 cfs, remaining at 94 percent of normal. In the southeastern part, flow southward through the Tamiami Canal outlets, 40-mile bend to Monroe, was 24 cfs, more than 4 times the normal flow at this time of year. Flow of Miami Canal at Miami decreased by 169 cfs, to 83 cfs, only 42 percent of normal.

Monthend contents of major reservoirs in the region were generally above average for March, but were below average in North Carolina.

Ground-water levels rose seasonally in most of the Southeast; but declined in much of West Virginia, in shallow bedrock aquifers of central Kentucky, and in heavily pumped areas of coastal Georgia and central and southeastern Florida. Levels near monthend remained above average in the Piedmont and mountain areas of North Carolina, and in Kentucky; were near average in

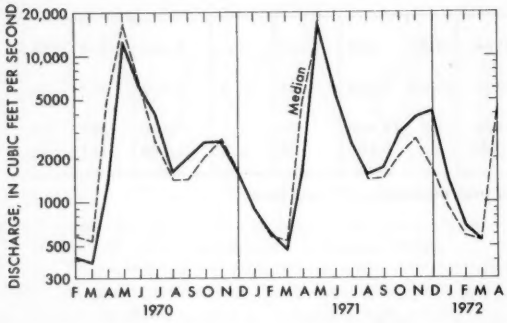
most of West Virginia; and remained near or below average in heavily pumped areas of Georgia and Florida.

WESTERN GREAT LAKES REGION

[Ontario; Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin]

STREAMFLOW DECREASED IN ONTARIO, BUT INCREASED IN THE 6 STATES OF THE REGION. FLOWS WERE IN THE ABOVE-NORMAL RANGE IN CENTRAL MINNESOTA AND FAR WESTERN ONTARIO; BELOW NORMAL IN AN AREA NEARLY SURROUNDING LAKE HURON; AND IN THE NORMAL RANGE ELSEWHERE.

North of Lake Huron, monthly mean discharge of Missinaibi River at Mattice, Ontario, decreased and was near median for March (see graph). The flows of many



Monthly mean discharge of Missinaibi River at Mattice, Ontario (Drainage area, 3,450 square miles.)

other streams in Ontario also decreased, but monthly mean discharges of several index stations were in the below-normal range—Aux Sables, Saugeen, and North Magnetawan Rivers. On the other hand, monthly and daily flows of English River at Umfreville in far western Ontario were again at or near record high levels for the month, continuing the carryover effects of higher flows in preceding months.

Near monthend, many streams in northern Michigan, Minnesota, and Wisconsin remained ice-covered. Major rises on streams in central and southern Minnesota—the result of spring snowmelt runoff—were even greater than usual for March. For example, for February, Crow River at Rockford and Buffalo River near Dilworth, monthly mean discharges were 272 cfs and 28 cfs respectively, and for March were 2,540 cfs and 686 cfs respectively.

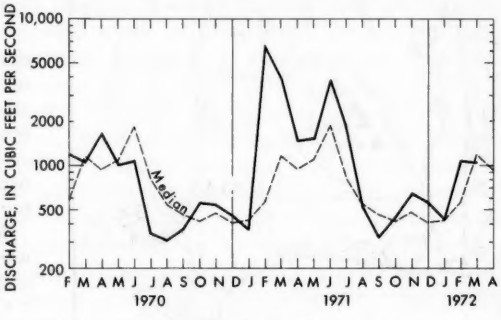
Ground-water levels generally began seasonal rises except in Michigan's Upper Peninsula. Monthend levels were near or above average in most of Michigan and Minnesota; slightly below average in Indiana; and continued below average in Ohio. Artesian levels continued to decline and remain below average in the heavily pumped Milwaukee, Wis., area; and declined slightly in the heavily pumped artesian aquifers in the Minneapolis-St. Paul, Minn., area.

MIDCONTINENT

[Manitoba and Saskatchewan; Arkansas, Iowa, Kansas, Louisiana, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas]

STREAMFLOW INCREASED IN THE DAKOTAS, IOWA, MISSOURI, AND LOUISIANA; AND GENERALLY DECREASED ELSEWHERE IN THE REGION. IN NORTH DAKOTA, STREAMFLOW WAS IN THE ABOVE-NORMAL RANGE, IN CONTRAST TO PERSISTING BELOW-NORMAL FLOWS IN MISSOURI, ARKANSAS, SOUTHERN OKLAHOMA, AND NORTHEASTERN TEXAS. IN SOUTHEASTERN TEXAS, LOCAL FLOODING OCCURRED MARCH 20TH ON SMALL STREAMS IN THE HOUSTON AREA.

The local flooding at Houston, Texas, resulted from intense rainfall in that area—reportedly totalling as much as 8 inches on the 20th, with a maximum intensity of 6 inches in 2 hours. Provisional peak discharges of 4 streams at Houston are given in the accompanying table. For 3 of the 4 stream-gaging sites listed, the recurrence interval was at least 25 years. Far different conditions characterized streamflow some 100 miles to the northeast—monthly mean discharge of Neches River near Rockland, Texas, was less than one third of median for the month. Low flows persisted also in Arkansas; in the northern part of the State, monthly mean discharge of Buffalo River near St. Joe, was only 15 percent of the March median. In northeastern Nebraska, streamflow decreased but was close to median for the month (see graph of Elkhorn River at Waterloo).



Monthly mean discharge of Elkhorn River at Waterloo, Neb. (Drainage area, 6,900 square miles.)

In the northern part of the Midcontinent, streamflow was in the above-normal range in North Dakota. Above-normal temperatures and consequent rapid snowmelt runoff resulted in flooding of some of the small towns in

the western part of the State by tributaries of the Missouri River, with large ice jams aggravating the problem. The daily discharge of Cannonball River at Breien in the south-central part of the State where the flow had ranged from 14 to 24 cfs during February, reached a daily flow of 18,700 cfs on March 15.

In Manitoba, monthly mean discharge of Waterhen River below Waterhen Lake, decreased but was more than 3 time the median flow for the month. The level of Lake Winnipeg at Gimli, averaged 715.26 feet above mean sea level, a rise of 0.24 foot, and was about 2.4 feet above the long-term mean for March.

Ground-water levels rose in Iowa; and changed only slightly in North Dakota, Kansas, and Nebraska. Month-end levels were near average in North Dakota and Nebraska; and in Iowa ranged from slightly below to considerably above average. In the rice-irrigation area of east-central Arkansas, levels rose slightly in the shallow aquifer (Quaternary deposits) and rose about 1½ feet in the deep aquifer (Sparta Sand); the level in the key well at Pine Bluff (Sparta Sand) declined slightly, and at El Dorado rose 3½ feet. In Texas, water levels rose at Austin and Houston, and declined at San Antonio and El Paso; monthend levels were above average at Austin, but below average at San Antonio, Houston, and El Paso.

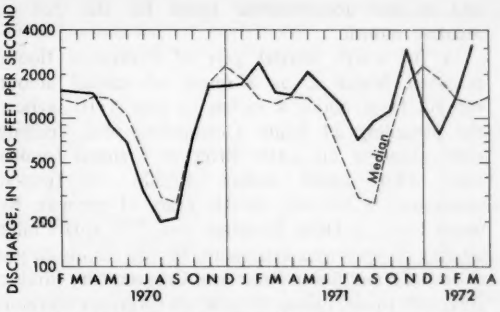
WEST

[Alberta and British Columbia; Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming]

STREAMFLOW DECREASED IN PARTS OF ARIZONA AND NEW MEXICO AND INCREASED ELSEWHERE IN THE REGION. ABOVE-NORMAL SNOWMELT RUNOFF RESULTING FROM UNUSUALLY HIGH TEMPERATURES AT LOWER ELEVATIONS, CHARACTERIZED THE NORTHERN HALF OF THE REGION AND INCLUDED MAXIMUM PEAK DISCHARGES OF RECORD ON SOME STREAMS IN THE NORTH COASTAL PART OF CALIFORNIA, AND MAXIMUM MONTHLY MEAN FLOWS ON STREAMS IN WASHINGTON, BRITISH COLUMBIA, IDAHO, AND MONTANA.

In Washington, highest monthly discharges of record for March occurred on Skykomish River near Gold Bar, 9,620 cfs (drainage area, 535 square miles; gaged since September 1928) and Spokane River at Spokane, 29,690 cfs, (drainage area, 4,290 square miles; gaged since April 1891). Highest monthly and highest daily discharge for March occurred on Chehalis River near Grand Mound, 9,590 cfs and 23,800 cfs (on 7th), respectively (drainage area, 895 square miles; gaged since October 1928).

In British Columbia, monthly mean discharge of Sproat River near Alberni (see graph), on Vancouver Island, was 3,290 cfs, highest for March in the 50 years of record.



Monthly mean discharge of Sproat River near Alberni, British Columbia (Drainage area, 134 square miles.)

In Idaho, highest monthly discharge of record for March occurred on Salmon River at White Bird, 10,260 cfs (drainage area, 13,550 square miles; period of record, 60 years), and on Snake River near Heise, 5,056 cfs (drainage area, 5,752 square miles; period of record, 62 years). New maximums for the month also occurred on Coeur d'Alene River at Enaville and Clearwater River at Orofino; and March flow was the highest since 1934 on St. Joe River at Calder in northern Idaho, since 1910 on Boise River above the reservoirs, and the third highest since 1913 on Weiser River near Weiser. The unusually large runoff was the combined result of rainfall and of snowmelt caused by above-normal temperatures. Snowpack at high altitudes, both north and south of Snake River, remained extremely heavy, posing a potential flood threat.

In Montana, highest March monthly mean flows in 61 years of record occurred on Clark Fork at St. Regis, 11,500 cfs (drainage area, 10,709 square miles), and Kootenai River at Libby, 10,170 cfs (drainage area, 10,240 square miles). A new maximum daily discharge for the month occurred on Yellowstone River at Corwin Springs, 1,680 cfs on the 23d (drainage area, 2,623 square miles). These high flows resulted from above-normal March temperatures which caused melting of the above-average snowpack at lower elevations.

In Wyoming, low-altitude snowmelt caused streamflow to be above normal throughout the State.

In Utah, flows of Weber River near Oakley and Big Cottonwood Creek near Salt Lake City in the north, continued in the above-normal range for the 10th consecutive month; while flow of Colorado River near Cisco in the east, remained in the above-normal range for the 7th consecutive month. The earlier-than-normal spring runoff from melting snow occurred because of record-breaking warm weather the first 3 weeks of March; at the Salt Lake City airport weather station, for example, daily mean temperature averaged 10 degrees above normal for the 3-week period.

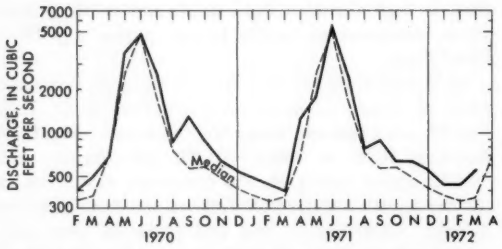
In northern Nevada, flow of Humboldt River at Palisade was almost 4 times the median for March

and in the above-normal range for the 22d consecutive month.

In the north coastal part of California, flooding occurred March 2 as a result of rainfall amounts varying from about 4 inches to almost 10 inches in the preceding 24 hours. Outstanding peak discharges were observed on Little River at Crannell (drainage area, 44.4 square miles), 12,300 cfs (previous maximum, 8,330 cfs, in 16 years of record); Redwood Creek at Orick (drainage area, 278 square miles), 49,700 cfs (previous maximum, 50,500 cfs, in 20 years of record); and Smith River near Crescent City (drainage area, 609 square miles) 174,000 cfs (previous maximum, 228,000 cfs, in 40 years of record). In southern California, streamflow continued in the below-normal range; January through March was the driest 3-month period in 99 years of observations by the Weather Bureau at Los Angeles.

In Arizona, streamflow was below the normal range throughout the State. Flow of Virgin River at Littlefield (drainage area, 5,090 square miles) was 87.3 cfs, roughly half that of February, and the lowest for March in 43 years of record.

In Colorado, streamflow was in the above-normal range in the southwest and west-central parts. Flow of Roaring Fork River at Glenwood Springs increased (see graph) and continued above the median for the 10th consecutive month. Flow of Animas River at Durango, in the southwest, was more than double that of February and continued to be above the normal range for the 6th consecutive month.



Monthly mean discharge of Roaring Fork River at Glenwood Springs, Colo. (Drainage area, 1,451 square miles.)

Contents of the Colorado River Storage Project increased 354,200 acre-feet during the month. In New Mexico, storage decreased in all reservoirs in the State and continued to be far below normal. In Utah, elevation of Great Salt Lake rose 0.30 foot during March, to 4,199.10 feet above mean sea level, 2.10 feet higher than a year ago.

Ground-water levels generally rose in Washington, Montana, and Utah; changed only slightly in Idaho; and declined in most wells in southern parts of California, Arizona, and New Mexico. Levels near monthend were above average in Washington, Montana, and eastern Utah; near or above average in Idaho; remained near average in southern California; and continued below average in southern Arizona and New Mexico.

ALASKA

Streamflow decreased at all four index stations in the State except Sheep Creek near Juneau, in the southeast, and was in the normal range at each of the stations except Chena River at Fairbanks, where streamflow continued in the above-normal range for the 6th consecutive month. Snow cover at end of month was above normal throughout Alaska, except north of the Yukon River.

Ground-water levels in the Anchorage area continued to decline.

HAWAII

Streamflow decreased at the four index stations in the State, becoming within the below-normal range at Waiakea Stream near Mountain View, Hawaii, and Honopou Stream near Huelo, Maui; the flows were 32 percent and 21 percent, respectively, of those of the preceding month. Minimum daily discharge of 0.63 cfs March 27, on Honopou Stream (drainage area, 0.64 square mile) was only 0.07 cfs greater than the March daily minimum for the 61 years of record.

ADDITION TO SERIES ON WATER IN THE URBAN ENVIRONMENT

The U.S. Geological Survey has recently published a new report in the series on water in the urban environment. The report is *Real-estate lakes*, by D.A. Rickert and A.M. Spieker: U.S. Geological Survey Circular 601-G, 19 pages, 1971. The purpose of the report is to describe the characteristics of real-estate lakes, to pinpoint potential problems, and to suggest possible planning and management guidelines for their solution. It is not intended as a construction manual nor is it intended to supplant on-site engineering planning. A real-estate lake, for the purposes of this report, is any body of water in the urban environment created or developed for the enhancement of real-estate value.

A copy of the report may be obtained free upon request to the U.S. Geological Survey, Distribution Section, 1200 S. Eads St., Arlington, Va. 22202. Other reports in this series that have been published to date are listed below:

U.S. GEOLOGICAL SURVEY CIRCULAR:

601-A. *Water for the cities—the outlook*, by W.J. Schneider and A.M. Spieker. 6 pages. 1969.
601-B. *Urban sprawl and flooding in southern California*, by S.E. Rantz. 11 pages. 1970.
601-C. *Flood-hazard mapping in metropolitan Chicago*, by J.R. Schaeffer and others. 14 pages. 1970.
601-D. *Water as an urban resource and nuisance*, by H.E. Thomas and W.J. Schneider. 9 pages. 1970.
601-E. *Sediment problems in urban areas*, by H.P. Guy. 8 pages. 1970.
601-F. *Hydrologic implications of solid-waste disposal*, by W.J. Schneider. 10 pages. 1970.

Provisional data; subject to revision

USABLE CONTENTS OF SELECTED RESERVOIRS NEAR END OF MARCH 1972

[Contents are expressed in percent of reservoir capacity. The usable storage capacity of each reservoir is shown in the column headed "Normal maximum."]

Reservoir Principal uses: F–Flood control I–Irrigation M–Municipal P–Power R–Recreation W–Industrial	End of Feb. 1972	End of Mar. 1972	End of Mar. 1971	Average for end of Mar.	Normal maximum
	Percent of normal maximum				
NORTHEAST REGION					
NOVA SCOTIA					
Rossignol, Mulgrave, Falls Lake, St. Margaret's Bay, Black, and Ponhook Reservoirs (P)	44	59	69	61	223,400 (a)
QUEBEC					
Gouin (P)	34	30	55	49	6,487,000 ac-ft
Allard (P)	29	32	18	29	280,600 ac-ft
MAINE					
Seven reservoir systems (MP)	21	18	24	32	179,300 mcf
NEW HAMPSHIRE					
Lake Winnipesaukee (PR)	55	69	51	60	7,200 mcf
Lake Francis (FPR)	17	12	7	18	4,326 mcf
First Connecticut Lake (P)	16	8	1	14	3,330 mcf
VERMONT					
Somerset (P)	62	58	38	49	2,500 mcf
Harriman (P)	22	11	8	32	5,060 mcf
MASSACHUSETTS					
Cobble Mountain and Borden Brook (MP)	80	80	69	76	3,394 mcf
NEW YORK					
Great Sacandaga Lake (FPR)	40	39	28	45	34,270 mcf
Indian Lake (FMP)	51	41	54	47	4,500 mcf
New York City reservoir system (MW)	87	98	89	.....	547,500 mg
NEW JERSEY					
Wanaque (M)	95	100	100	88	27,730 mg
PENNSYLVANIA					
Wallenpaupack (P)	72	81	77	64	6,875 mcf
Pymatuning (FMR)	78	100	102	92	8,191 mcf
MARYLAND					
Baltimore municipal system (M)	101	101	100	90	85,340 mg
SOUTHEAST REGION					
NORTH CAROLINA					
Bridgewater (Lake James) (P)	79	79	85	90	12,580 mcf
High Rock Lake (P)	65	68	66	84	10,230 mcf
Narrows (Badin Lake) (P)	99	99	101	102	5,616 mcf
SOUTH CAROLINA					
Lake Murray (P)	82	85	94	76	70,300 mcf
Lakes Marion and Moultrie (P)	90	86	85	78	81,100 mcf
SOUTH CAROLINA––GEORGIA					
Clark Hill (FP)	70	73	81	71	75,360 mcf
GEORGIA					
Burton (PR)	77	91	90	82	104,000 ac-ft
Lake Sidney Lanier (FMPR)	61	60	59	56	1,686,000 ac-ft
Sinclair (MPR)	91	88	94	90	214,000 ac-ft
ALABAMA					
Lake Martin (P)	90	90	98	89	1,373,000 ac-ft
TENNESSEE VALLEY					
Clinch Projects: Norris and Melton Hill Lakes (FPR)	55	59	58	45	1,166,000 cfsd
Holston Projects: South Holston, Watauga, Boone, Fort Patrick Henry, and Cherokee Lakes (FPR)	58	63	57	53	1,452,000 cfsd
Douglas Lake (FPR)	27	43	41	40	715,800 cfsd
Hiwassee Projects: Chatuge, Nottely, Hiwassee, Apalachia, Blue Ridge, Ocoee 3, and Parksville Lakes (FPR)	60	69	71	61	523,700 cfsd
Little Tennessee Projects: Nantahala, Thorpe, Fontana, and Chilhowee Lakes (FPR)	60	70	69	60	751,400 cfsd
WESTERN GREAT LAKES REGION					
WISCONSIN					
Chippewa and Flambeau (PR)	32	30	16	23	15,900 mcf
Wisconsin River (21 reservoirs) (PR)	20	12	10	23	17,400 mcf
MINNESOTA					
Mississippi River headwater system (FMR)	21	21	13	18	1,640,000 ac-ft

Reservoir Principal uses: F–Flood control I–Irrigation M–Municipal P–Power R–Recreation W–Industrial	End of Feb. 1972	End of Mar. 1972	End of Mar. 1971	Average for end of Mar.	Normal maximum
	Percent of normal maximum				
MIDCONTINENT REGION					
NORTH DAKOTA					
Lake Sakakawea (Garrison) (FIPR)	84	98	88	.....	22,640,000 ac-ft
NEBRASKA					
Lake McConaughy (IP)	88	91	91	75	1,948,000 ac-ft
OKLAHOMA					
Keystone (FPR)	84	83	92	91	661,000 ac-ft
Lake O' The Cherokees (FPR)	83	80	81	84	1,492,000 ac-ft
Tenkiller Ferry (FPR)	91	85	92	88	628,200 ac-ft
Lake Altus (FIMR)	22	21	21	54	134,500 ac-ft
Eufaula (FPR)	80	80	79	80	2,378,000 ac-ft
OKLAHOMA––TEXAS					
Lake Texoma (FMPRW)	86	81	84	86	2,722,000 ac-ft
TEXAS					
Possum Kingdom (IMPRW)	94	94	60	76	724,500 ac-ft
Buchanan (IMPW)	95	96	85	76	955,200 ac-ft
Bridgeport (IMW)	62	61	79	61	270,900 ac-ft
Eagle Mountain (IMW)	96	94	89	85	182,700 ac-ft
Medina Lake (I)	98	97	56	47	254,000 ac-ft
Lake Travis (FIMPRW)	95	93	91	77	1,144,000 ac-ft
Lake Kemp (IMW)	28	27	31	53	461,800 ac-ft
THE WEST					
ALBERTA					
Spray (P)	20	34	7	20	210,000 ac-ft
Lake Minnewanka (P)	50	49	29	30	199,700 ac-ft
St. Mary (I)	72	81	65	67	320,800 ac-ft
WASHINGTON					
Franklin D. Roosevelt Lake (IP)	51	26	32	53	5,232,000 ac-ft
Lake Chelan (PR)	16	29	27	31	676,100 ac-ft
IDAHO––WYOMING					
Upper Snake River (7 reservoirs) (IMP)	76	77	80	78	4,282,000 ac-ft
WYOMING					
Pathfinder, Seminoe, Alcova, Kortes, and Glendo Reservoirs (I)	72	71	62	35	3,016,000 ac-ft
Buffalo Bill (IP)	59	55	44	61	421,300 ac-ft
Boysen (FIP)	75	71	56	61	802,000 ac-ft
Keyhole (F)	79	93	64	32	199,900 ac-ft
COLORADO					
John Martin (FIR)	7	7	10	22	364,400 ac-ft
Colorado–Big Thompson project (I)	75	75	79	52	722,600 ac-ft
Taylor Park (IR)	64	66	87	57	106,000 ac-ft
COLORADO RIVER STORAGE PROJECT					
Lake Powell; Flaming Gorge, Navajo, and Blue Mesa Reservoirs (IFPR)	54	55	49	.....	31,276,500 ac-ft
UTAH––IDAHO					
Bear Lake (IPR)	76	79	77	56	1,421,000 ac-ft
CALIFORNIA					
Hetch Hetchy (MP)	20	23	32	27	360,400 ac-ft
Lake Almanor (P)	59	68	82	48	1,036,000 ac-ft
Shasta Lake (FIPR)	79	92	98	83	4,377,000 ac-ft
Millerton Lake (FI)	66	59	70	61	503,200 ac-ft
Pine Flat (FI)	45	43	66	52	1,014,000 ac-ft
Isabella (FIR)	22	21	29	24	551,800 ac-ft
Folsom (FIP)	57	71	79	59	1,000,000 ac-ft
Lake Berryessa (FIMW)	87	87	101	88	1,600,000 ac-ft
Clair Engle Lake (Lewiston) (P)	85	95	95	86	2,438,000 ac-ft
CALIFORNIA––NEVADA					
Lake Tahoe (IPR)	70	74	75	55	744,600 ac-ft
NEVADA					
Rye Patch (I)	100	105	106	52	179,100 ac-ft
ARIZONA––NEVADA					
Lake Mead and Lake Mohave (FIMP)	69	67	64	62	27,970,000 ac-ft
ARIZONA					
San Carlos (IP)	13	11	0	20	948,600 ac-ft
Salt and Verde River system (IMPR)	50	48	50	45	2,073,000 ac-ft
NEW MEXICO					
Conchas (FIR)	44	44	68	.....	352,600 ac-ft
Elephant Butte and Caballo (FIPR)	11	9	14	.....	2,539,000 ac-ft

[a] Thousands of kilowatt-hours.

PERIODIC REPORTS ON GROUND-WATER LEVELS IN THE UNITED STATES, 1935–70

Publication of records of water levels in the United States in the annual series of water-supply papers was begun by the Geological Survey in 1935. From 1935 through 1939, one volume per year was issued—Water-Supply Papers 777, 817, 840, 845, and 886, respectively. For the years 1940 through 1955, the nationwide data were subdivided into six regions, and thus six volumes of water-level records were published for each of those years. Since 1955, the period of time covered in each volume has been increased, so that now each regional volume contains five years of water-level data.

Beginning in 1956, water-level data from only a *basic network* of observation wells have been published. This basic network consists of observation wells located insofar as possible where the most significant data can be obtained from the fewest wells in the most important aquifers. In some States the basic network forms the skeletal index of a more comprehensive observation-well program carried out in cooperation with State and other governmental agencies. Publications that contain substantial additional water-level data are listed as references in the 5-year volumes following the water-level data for each State. The tables below identify the water-supply paper (WSP) number of the report containing water-level records for a given year and also the regional classification of each State in this series of reports.

Water-supply papers are available for reference in many large public and university libraries and in the district offices of the U.S. Geological Survey. Water-supply papers still in print may be purchased from the Superintendent of Documents (Government Printing Office, Washington, D.C. 20402), including Water-Supply Papers 1855 ($0.60), 1976 ($0.55), 1977 ($1.00), 1978 ($1.00), 1979 ($1.00), and 1980 ($1.00).

In the collection of water-level data for the observation-well program, the principal objective is to measure *changes* in water level accurately, rather than to determine the absolute position of the water surface. Because the measurements are made in many types of wells, under varying conditions of access and at different temperatures, neither the method of measurement nor the equipment can be completely uniform. At each observation well, however, the best possible combination of measuring technique and equipment is used, and so long as it is not changed, the measurements at each well will be consistent. Water-level measurements are given in feet with reference to either mean sea level or land-surface datum. Mean sea level is the datum plane on which the national network of water levels is based; land-surface datum is a precise datum plane that is approximately at land surface at each well. If known, the altitude of the land-surface datum above mean sea level is given in the well description. Measurements of water levels in wells equipped with recording gages are given for every fifth day and the last day of each month.

Year, regions (groups of States), and report numbers of annual and five-year reports on water levels in observation wells in the United States, 1935–70

Calendar year	Water-supply paper number						Calendar year	Water-supply paper number					
	Northeastern States (part 1)	Southeastern States (part 2)	North-central States (part 3)	South-central States (part 4)	Northwestern States (part 5)	Southwestern States (part 6)		Northeastern States (part 1)	Southeastern States (part 2)	North-central States (part 3)	South-central States (part 4)	Northwestern States (part 5)	Southwestern States (part 6)
1935	777	777	777	777	777	777	1953	1265	1266	1267	1268	1269	1270
1936	817	817	817	817	817	817	1954	1321	1322	1323	1324	1325	1326
1937	840	840	840	840	840	840	1955	1404	1405	1406	1407	1408	1409
1938	845	845	845	845	845	845	1956	1537	1538	1456	1549	1760	1770
1939	886	886	886	886	886	886	1957	1537	1538	1781	1549	1760	1770
1940	906	907	908	909	910	911	1958	1782	1538	1781	1549	1760	1770
1941	936	937	938	939	940	941	1959	1782	1803	1781	1549	1760	1770
1942	944	945	946	947	948	949	1960	1782	1803	1781	1824	1760	1770
1943	986	987	988	989	990	991	1961	1782	1803	1781	1824	1845	1855
1944	1016	1017	1018	1019	1020	1021	1962	1782	1803	1976	1824	1845	1855
1945	1023	1024	1025	1026	1027	1028	1963	1977	1803	1976	1824	1845	1855
1946	1071	1072	1073	1074	1075	1076	1964	1977	1978	1976	1824	1845	1855
1947	1096	1097	1098	1099	1100	1101	1965	1977	1978	1976	1979	1845	1855
1948	1126	1127	1128	1129	1130	1131	1966	1977	1978	1976	1979	1980	(a)
1949	1156	1157	1158	1159	1160	1161	1967	1977	1978	(a)	1979	1980	(a)
1950	1165	1166	1167	1168	1169	1170	1968	(a)	1978	(a)	1979	1980	(a)
1951	1191	1192	1193	1194	1195	1196	1969	(a)	(a)	(a)	1979	1980	(a)
1952	1221	1222	1223	1224	1225	1226	1970	(a)	(a)	(a)	(a)	1980	(a)

[a]Report in preparation.

Years of water-level records and number of wells described in most-recently-published water-supply papers (WSP), by States

State	Region (part number)	Annual WSP in which records first appeared	Most-recently-published WSP			State	Region (part number)	Annual WSP in which records first appeared	Most-recently-published WSP		
			WSP number	Years of records in WSP	Number of wells described				WSP number	Years of records in WSP	Number of wells described
Alabama	SE(2)	907	1978	1964–68	49	Montana	NW(5)	777	1980	1966–70	24
Alaska	NW(5)	1760	1980	1966–70	23	Nebraska	NC(3)	777	1976	1962–66	74
Arizona	SW(6)	886	1855	1961–65	103	Nevada	SW(6)	1170	1855	1961–65	108
Arkansas	SC(4)	777	1979	1965–69	67	New Hampshire	NE(1)	986	1977	1963–67	5
California	SW(6)	777	1855	1961–65	183	New Jersey	NE(1)	777	1977	1963–67	26
Colorado	NW(5)	817	1980	1966–70	61	New Mexico	SW(6)	777	1855	1961–65	118
Connecticut	NE(1)	777	1977	1963–67	21	New York	NE(1)	777	1977	1963–67	45
Delaware	NE(1)	1016	1977	1963–67	10	North Carolina	SE(2)	777	1978	1964–68	56
District of Columbia	SE(2)	907	937	1941	4	North Dakota	NC(3)	817	1976	1962–66	39
Florida	SE(2)	777	1978	1964–68	152	Ohio	NE(1)	845	1977	1963–67	58
Georgia	SE(2)	845	1978	1964–68	90	Oklahoma	SC(4)	777	1979	1965–69	28
Hawaii	SW(6)	777	1855	1961–65	52	Oregon	NW(5)	777	1980	1966–70	120
Idaho	NW(5)	777	1980	1966–70	114	Pennsylvania	NE(1)	777	1977	1963–67	53
Illinois	NC(3)	946	1976	1962–66	3	Rhode Island	NE(1)	1023	1977	1963–67	18
Indiana	NE(1)	777	1977	1963–67	69	South Carolina	SE(2)	777	1978	1964–68	23
Iowa	NC(3)	777	1976	1962–66	49	South Dakota	NC(3)	817	1976	1962–66	20
Kansas	NC(3)	777	1976	1962–66	33	Tennessee	SE(2)	817	1978	1964–68	36
Kentucky	SE(2)	1017	1978	1964–68	53	Texas	SC(4)	777	1979	1965–69	702
Louisiana	SC(4)	845	1979	1965–69	118	Utah	NW(5)	777	1980	1966–70	185
Maine	NE(1)	986	1977	1963–67	13	Vermont	NE(1)	986	1977	1963–67	3
Maryland	SE(2)	817	1978	1964–68	20	Virginia	SE(2)	777	1978	1964–68	18
Massachusetts	NE(1)	886	1977	1963–67	21	Washington	NW(5)	777	1980	1966–70	228
Michigan	NE(1)	777	1977	1963–67	61	West Virginia	SE(2)	937	1978	1964–68	19
Minnesota	NC(3)	908	1976	1962–66	23	Wisconsin	NC(3)	777	1976	1962–66	83
Mississippi	SE(2)	845	1978	1964–68	62	Wyoming	NW(5)	910	1980	1966–70	129
Missouri	NC(3)	777	1976	1962–66	3						

TWO NEW PUBLICATIONS ON GROUND WATER

The U.S. Geological Survey has recently published two papers that are of considerable importance to scientists and engineers working in the disciplines of ground-water hydrology and hydraulics. One of the reports is *Definitions of selected ground-water terms—revisions and conceptual refinements*, by S.W. Lohman and others: U.S. Geological Survey Water-Supply Paper 1988, 21 pages, 1972. It is a report of the Committee on Redefinition of Ground-Water Terms—R.R. Bennett, R.H. Brown, H.H. Cooper, W.J. Drescher, J.G. Ferris, A.I. Johnson, S.W. Lohman, C.L. McGuinness, A.M. Piper, M.I. Rorabaugh, R.W. Stallman, and C.V. Theis. The definitions pertain to the following 39 terms:

aquifer
artesian
capillary fringe
capture
conductivity, effective hydraulic
conductivity, hydraulic
confining bed
flow, steady
flow, uniform
flow, unsteady
fluid potential
ground water, confined
ground water, perched
ground water, unconfined
head, static
head, total
homogeneity
hydraulic diffusivity
hydraulic gradient
isotropy
permeability, intrinsic
porosity
porosity, effective
potentiometric surface
pressure, static
specific capacity
specific discharge (specific flux)
specific retention
specific yield
storage, bank
storage, specific
storage coefficient
stream, gaining
stream, losing
transmissivity
velocity, average interstitial
water table
zone, saturated
zone, unsaturated

The other report is *Ground-water hydraulics*, by S.W. Lohman: U.S. Geological Survey Professional Paper 708, 70 pages, 1972. The background and content of this second report are summarized in the following excerpt from Mr. Lohman's introduction:

"The science of ground-water hydrology is concerned with evaluating the occurrence, availability, and quality of ground water. Although many ground-water investigations are qualitative in nature, quantitative studies are necessarily an integral part of the complete evaluation of occurrence and availability. The worth of an aquifer as a source of water depends largely upon two inherent characteristics—its ability to store and to transmit water.

"Thorough knowledge of the geologic framework is essential to understand the operation of the natural plumbing system within it. Ground-water hydraulics is concerned with the natural or induced movement of water through permeable rock formations. The principal method of analysis in ground-water hydraulics is the application, generally by field tests of discharging wells, of equations derived from particular boundary conditions. Prior to 1935, such equations were known only for the relatively simple steady flow condition, which incidentally generally does not occur in nature. The development by C.V. Theis of an equation for the non-steady flow of ground water was a milestone in ground-water hydraulics. Since 1935 the number of equations and methods has grown rapidly and steadily. These are described in a wide assortment of publications, some of which are not conveniently available to many engaged in ground-water studies. The essence of many of these will be presented and briefly discussed, but frequent recourse should be made to the more exhaustive treatments given in the references cited.

"The material presented herein was adapted from the lecture notes which I prepared for a series of five lectures on ground-water hydraulics presented in May 1967 to the students of the 1967 Ground Water School of the Australian Water Resources Council at Adelaide, South Australia. Problems given in the lecture notes have been changed to examples in this report, and the solutions of these examples are complete with tabulated data and data plots. Nine plates and three figures of type curves are reproduced at scales to fit readily available logarithmic or semilogarithmic translucent graph paper, and most of the data plots also are reproduced at scales to fit the proper type curves. Thus, all the type curves may be used in the solution of actual field problems."

Professional Paper 708 and Water-Supply Paper 1988 may be purchased for $2.00 and $0.25, respectively, from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

An earlier Geological Survey report on the ground-water hydraulics of aquifer tests was published 10 years ago and is now out of print and no longer available for purchase. The report, *Theory of aquifer tests*, by J.G. Ferris, D.B. Knowles, R.H. Brown, and R.W. Stallman: U.S. Geological Survey Water Supply Paper 1536-E (174 pages; 1962), may be consulted in many of the larger public and university libraries as well as in offices of the Geological Survey.

HYDROGRAPHS OF SOME MAJOR RIVERS, SEPTEMBER 1969 TO MARCH 1972

DISCHARGE, IN THOUSANDS OF CUBIC FEET PER SECOND

1. Fraser River at Hope, British Columbia
(Drainage area, 78,300 sq mi)

2. Columbia River at The Dalles, Oreg.
(Drainage area, 237,000 sq mi)

3. Mississippi River near Vicksburg, Miss.
(Drainage area, 1,144,500 sq mi)

4. Ohio River at Louisville, Ky.
(Drainage area, 91,170 sq mi)

5. Missouri River at Hermann, Mo.
(Drainage area, 528,200 sq mi)

6. St. Lawrence River at Lake St. Lawrence
(Drainage area, 295,200 sq mi)

7. Delaware River at Trenton, N. J.
(Drainage area, 6,780 sq mi)

8. Susquehanna River at Harrisburg, Pa.
(Drainage area, 24,100 sq mi)

9. Potomac River near Washington, D. C.
(Drainage area, 11,560 sq mi)

10. Altamaha River at Doctortown, Ga.
(Drainage area, 13,600 sq mi)

11. Tombigbee River at Demopolis lock and dam, near Coatopa, Ala.
(Drainage area 15,480 sq mi)

1969 1970 1971 1972
S D M J S D M J S D M

Median

Provisional data; subject to revision

FLOW OF MAJOR RIVERS DURING MARCH 1972

River and location	Drainage area (square miles)	Mean annual discharge through September 1970 (cfs)	March 1972					
			Monthly mean discharge (cfs)	Percent of median monthly discharge[1]	Change in discharge from previous month (percent)	Discharge near end of month		
						(cfs)	(mgd)	Date
St. Lawrence River at Lake St. Lawrence[2]	295,200	239,100	254,500	113	+ 10	280,000	181,000	31
Delaware River at Trenton, N.J	6,780	11,360	25,310	124	+141	22,500	14,500	28
Susquehanna River at Harrisburg, Pa	24,100	33,670	108,100	156	+317	48,000	31,000	31
Potomac River near Washington, D.C	11,560	10,650	27,900	132	+ 3	12,000	7,760	31
Altamaha River at Doctortown, Ga	13,600	13,380	21,460	93	- 52	19,300	12,500	24
Tombigbee River near Coatopa, Ala[3]	15,400	22,160	32,903	70	+ 6	16,000	10,300	31
Missouri River at Hermann, Mo	528,200	77,480	59,950	84	+ 54	57,800	37,400	28
Ohio River at Louisville, Ky[4]	91,170	110,600	287,800	132	+ 45	197,800	128,000	28
Mississippi River near Vicksburg, Miss[5]	1,144,500	552,700	806,400	96	+ 45	738,000	477,000	31
Colorado River near Grand Canyon, Ariz	137,800	.....	5,645	.....	- 30	.....	.....	.....
Columbia River at The Dalles, Oreg[6]	237,000	194,000	321,200	277	+152	.....	.....	.....
Fraser River at Hope, British Columbia	78,300	95,300	53,300	246	+ 84	73,900	47,800	29

[1]Reference period 1931–60 or 1941–70.

[2]Records furnished by Department of the Army, Corps of Engineers, Buffalo District. Discharges shown are considered to be the same as those at Ogdensburg, N.Y., which is directly opposite Prescott, Ontario.

[3]At Demopolis lock and dam.

[4]Records furnished by U.S. Army, Corps of Engineers.

[5]Records of daily discharge computed jointly by Corps of Engineers and Geological Survey.

[6]Discharge (adjusted for upstream storage) determined from information furnished by Bureau of Reclamation, Corps of Engineers, and Geological Survey.

WATER RESOURCES REVIEW — MARCH 1972

Cover map shows generalized pattern of streamflow for March based on 22 index stream-gaging stations in Canada and 130 index stations in the United States. Alaska and Hawaii inset maps show streamflow only at the index gaging stations which are located near the points shown by the arrows.

Streamflow for March 1972 is compared with flow for March in the 30-year reference period 1931–60 or 1941–70. Streamflow is considered to be *below normal* if it is within the range of the low flows that have occurred 25 percent of the time (below the lower quartile) during the reference period. Flow for March is considered to be *above normal* if it is within the range of the high flows that have occurred 25 percent of the time (above the upper quartile).

Flow higher than the lower quartile but lower than the upper quartile is described as being within the *normal range.* In the Water Resources Review *normal flow* is defined as the median of the 30 flows of March during the reference period. The normal (median) has been obtained by ranking those 30 flows in their order of magnitude; the highest flow is number 1, the lowest flow is number 30, and the average of the 15th and 16th highest flows is the normal (median).

The normal is an average (but not an arithmetic average) or middle value; half of the time you would expect the March flows to be below the median and half of the time to be above the median. Shorter reference periods are used for the Alaska index stations because of the limited records available.

Statements about *ground-water levels* refer to conditions near the end of March. Water level in each key observation well is compared with average level for the end of March determined from the entire past record for that well or from a 20-year reference period, 1951–70. *Changes in ground-water levels* unless described otherwise, are from the end of February to the end of March.

The Water Resources Review is published monthly. Special-purpose and summary issues are also published. In the United States, issues of the Review are free on application to the Water Resources Review, U.S. Geological Survey, Washington, D.C. 20242.

This issue was prepared by J.C. Kammerer, H.D. Brice, E.W. Coffay. and L.C. Fleshmon from reports of the field offices, April 6, 1972.

UNDERGROUND STORAGE OF IMPORTED WATER IN THE SAN GORGONIO PASS AREA, SOUTHERN CALIFORNIA

The accompanying abstract, maps, and table are from the report, *Underground storage of imported water in the San Gorgonio Pass area, southern California,* by R.M. Bloyd, Jr.: U.S. Geological Survey Water-Supply Paper 1999-D, 37 pages, 1971; prepared in cooperation with the San Gorgonio Pass Water Agency. Water-Supply Paper 1999-D may be purchased for $1.00 from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

ABSTRACT

The San Gorgonio Pass ground-water basin (fig. 1) is divided into the Beaumont, Banning, Cabazon, San Timoteo, South Beaumont, Banning Bench, and Singleton storage units. The Beaumont storage unit, centrally located in the agency area, is the largest in volume of the storage units.

Estimated long-term average annual precipitation in the San Gorgonio Pass Water Agency drainage area (fig. 2) is 332,000 acre-feet and estimated average annual recoverable water is 24,000 acre-feet, less than 10 percent of the total precipitation. Estimated average annual surface outflow is 1,700 acre-feet, and estimated average annual ground-water recharge is 22,000 acre-feet. Projecting back to probable steady-state conditions, of the 22,000 acre-feet of recharge, 16,000 acre-feet per year became subsurface outflow into Coachella Valley, 6,000 acre-feet into the Redlands area, and 220 acre-feet into Potrero Canyon. (table 1).

After extensive development, estimated subsurface outflow from the area in 1967 was 6,000 acre-feet into the Redlands area, 220 acre-feet into Potrero Canyon, and 800 acre-feet into the fault systems south of the Banning storage unit, unwatered during construction of a tunnel. Subsurface outflow into Coachella Valley in 1967 is probably less than 50 percent of the steady-state flow.

An anticipated 17,000 acre-feet of water per year will be imported by 1980. Information developed in this study indicates it is technically feasible to store imported water in the eastern part of the Beaumont storage unit without causing waterlogging in the storage area and without losing any significant quantity of stored water.

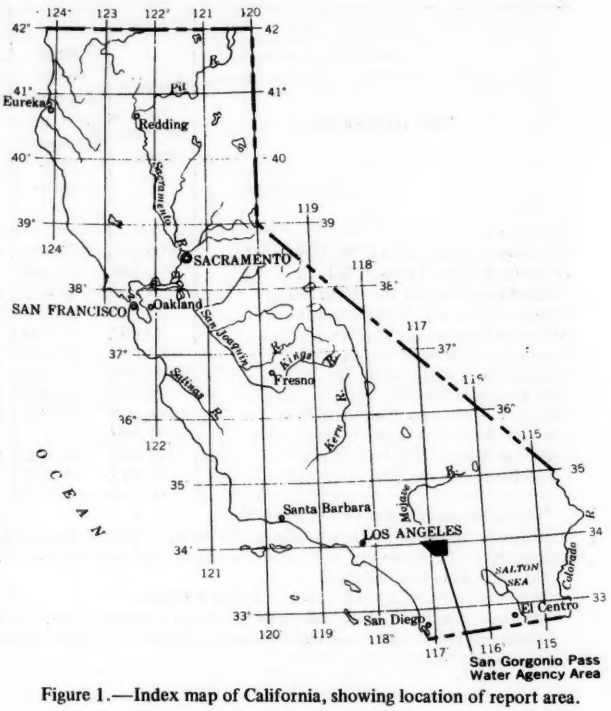


Figure 1.—Index map of California, showing location of report area.

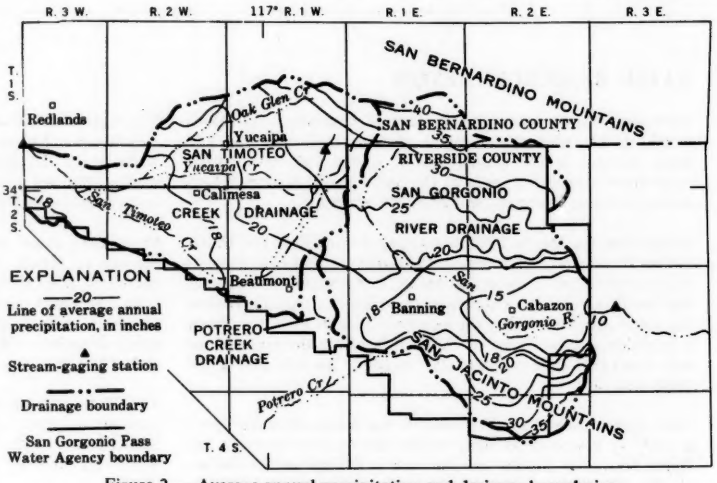


Figure 2.—Average annual precipitation and drainage boundaries.

Table 1.—*Steady-state hydrologic budget, in acre-feet*

Item	Drainage basin (average annual quantity)			Total agency drainage
	San Timoteo Creek	San Gorgonio River	Potrero Creek	
Precipitation	136,000	188,000	8,000	332,000
Recoverable water	7,000	16,700	250	≈24,000
Surface outflow	870	800	30	1,700
Ground-water recharge	6,000	16,000	220	≈22,000
Subsurface outflow	6,000	16,000	220	≈22,000

INT: 5811-72